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# INVESTIGATION OF COAL RIVER BASIN. REPORT ON BENEFITS TO WATER SUPPLY AND POLLUTION ABATEMENT FROM LOW-FLOW AUGMENTATION ON THE COAL RIVER AND TRIBUTARIES IN WEST VIRGINIA

Public Health Service
Charlottesville, Virginia

March 1961

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# INVESTIGATION OF

# THE COAL RIVER BASIN

## Report on Benefits to Water Supply and Pollution Abatement from Low-Flow Augmentation on the Coal River and Tributaries

Prepared at the request of and in cooperation with
the District Engineer, Huntington District
Corps of Engineers, U. S. Army

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services
Division of Water Pollution Control

REGION III
Charlottesville, Virginia

March 1961



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West Virginia State Department of Health

West Virginia State Water Resources Commission

West Virginia Water Service Company

Local water treatment plant operators and city officials

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## INTRODUCTION

The District Engineer, Huntington Corps of Engineers, by letter dated September 23, 1960, requested that the Public Health Service make a preliminary study of water supply and pollution abatement benefits which might accrue from low-flow augmentation in conjunction with proposals for reservoirs which may operate to provide increased low-water flows in the Coal River Basin, West Virginia. The request was in accordance with the Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare to provide assistance in implementing the Water Supply Act of 1958 (Title III, Public Law 500, 85th Congress).

This report contains the findings of the Public Health Service investigation, including an evaluation of water supply and pollution abatement benefits that could accrue to proposed reservoirs on Marsh Fork and Clear Fork, tributaries to the Coal River. The proposed reservoirs would provide increased stream flow during natural low-flow periods. The report also includes information concerning water supplies, pollution sources, and general water quality in the Coal River Basin, as obtained in a field investigation, October 24, 1960, to October 28, 1960.

## SUMMARY

1. The Coal River Basin contains a large portion of one of the greatest bituminous coal reserves in the country and is located near the industrial and metropolitan area of the Kanawha River and Charleston, West Virginia.

2. The two reservoir sites under consideration by the Corps of Engineers are located in the upper reaches of Marsh Fork and Clear Fork, tributaries of the Coal River.

3. Due to the location of reservoir sites, communities located along Little Coal River will not realize water supply or pollution abatement benefits from the proposed plans for low-flow augmentation.

4. The discharge of coal fines into the streams of the basin has, in the past, been a major source of pollution; however, recent control activities of the West Virginia Water Resources Commission have been successful and fifteen of the sixteen coal washeries in the basin now have treatment facilities to reduce the discharge of coal fines into the streams.

5. In the portion of the basin which would be affected by the proposed plans for low-flow augmentation, there are nine public water supplies serving approximately 22,000 persons using about

1.16 million gallons per day. Approximately 99 per cent of these people presently receive their water supply from surface water sources.

6. None of the communities located on Marsh Fork, Clear Fork, or the Coal River presently have public sewage treatment facilities.

7. Long periods of extremely low flow occur in the Coal River Basin. During these periods, water quantity is inadequate for projected water needs and water quality is adversely affected.

8. Minimum low flow in the Coal River at Ashford, West Virginia, was zero in 1930. Stream flow for design of sewage treatment facilities (minimum average 7-day low flow occurring on a 10-year frequency) for the Coal River at Ashford, West Virginia, is 2.0 cfs.

9. Ground water in the Coal River Basin contains high concentrations of iron, hydrogen sulfide, and hardness salts, thus making it difficult and expensive to treat for water supply use.

10. On the basis of raw water quality and costs to produce water of acceptable quality for domestic purposes, surface water is the most desirable and economical source in the Coal River Basin.

11. Treatment of all municipal sewage discharges in the basin with provisions for chlorination of the treatment plant effluent would be necessary to preserve water quality for domestic use.

12. Based on the anticipated future waste discharges and the calculated natural assimilative capacity 1/ of Little Coal River, it was considered, for purposes of this study, that Little Coal River would neither add to nor depreciate significantly the oxygen resources of the Coal River.

13. The nature of the Coal River Basin is such that maximum pollution abatement benefits would be realized by communities in the upper reaches of the basin, while maximum water supply benefits would be realized in the area adjacent to the mouth of the river.

14. The following annual water supply and pollution abatement benefits would accrue to the reservoirs under consideration:

| Plan | Flow Increase | Reservoir Site | ANNUAL BENEFITS | | |
|---|---|---|---|---|---|
| | | | Water Supply | Pollution Abatement | |
| | | | | Prim. Trmt. Period | Sec. Trmt. Period |
| I(a) | 5 | Marsh Fork | $ 24,700 | $ 21,800 | $ 4,250 |
| (b) | 20 | " " | 24,700 | 21,800 | 4,250 |
| II(a) | 5 | Clear Fork | 24,700 | 14,100 | 2,400 |
| (b) | 20 | " " | 24,700 | 14,100 | 2,400 |
| III | 40 | Marsh Fork and Clear Fork* | 162,500 | 24,200 | 5,300 |

* Plan III is a combination of Plan I(b) and Plan II(b).

1/ Capacity of stream to oxidize waste loads by self-purification processes.

15. Assured increases in stream flow during low-flow periods could have a favorable impact on the general growth and economy of the basin by providing water of suitable quality and quantity for municipal, industrial, and recreational uses.

COAL RIVER BASIN
WEST VIRGINIA

SCALE:

## DESCRIPTION

### THE AREA

The Coal River Basin is located in southwestern West Virginia, south and west of Charleston, and drains an area of 899 square miles. The basin includes portions of Putnam, Kanawha, Lincoln, Boone, Logan, and Raleigh Counties. The general terrain of the area is hilly to mountainous with narrow, steep valleys, especially in the upper reaches. Coal mining is the predominant economic activity in the area, which contains a large part of one of the greatest bituminous coal reserves in the country.

The Coal River forms at Whitesville, West Virginia, at the confluence of Clear Fork (draining 62 square miles), and Marsh Fork (draining 163 square miles). It then flows northwesterly 56 miles to discharge into the Kanawha River at Saint Albans, West Virginia. The principal tributary is the Little Coal River which drains 386 square miles, approximately 43 per cent of the entire basin area, and enters Coal River about 17.4 miles above its mouth.

### HYDRAULICS

The United States Geological Survey has two gaging stations in the basin with continuous records dating back to 1930. One station is located on the Coal River at Ashford, West Virginia, 28.2 miles upstream from the mouth, while the other station is located on the Little Coal River at Danville, West Virginia. Flows at Ashford have ranged from a

minimum of zero flow to a maximum of 35,800 cfs with a mean of 499 cfs. Flows at Danville have ranged from a minimum of zero flow to a maximum of 42,800 cfs with a mean flow of 334 cfs.

Due to the mountainous topography of the basin, high rates of runoff occur and are greatest during winter months. Floods on the Coal River are of short duration, seldom remaining above flood stage more than 12 hours. In contrast to the short-duration floods are the long periods of low flow which occur frequently. At such times the streams of the basin are unsatisfactory for certain water uses, including water supply, waste assimilation, and recreation.

## POPULATION AND INDUSTRIAL DATA

According to the 1950 census, approximately 65,790 persons reside in the Coal River Basin with 35,430 (or 54 per cent) living in towns with over 300 population. A recent decrease in population of the basin has occurred, however, and early 1960 census reports indicate the following population trends for the counties of this area:

| County | 1950 to 1960 % Increase or Decrease |
|---|---|
| * Boone | - 13.3 |
| Kanawha | 5.5 |
| Lincoln | - 9.8 |
| Logan | - 20.4 |
| Putnam | 12.1 |
| * Raleigh | - 19.2 |

* Counties containing majority of benefiting communities.

Saint Albans, West Virginia, is the largest community in the basin with a 1960 population of about 15,000. The next largest community in the portion of the basin which would be affected by proposed plans for low-flow augmentation is Whitesville, with a population of about 2,000.

In estimating future populations for the determination of water supply and pollution abatement benefits, it is assumed that communities which have shown population increases will experience a continuation of their past trend, and communities which have lost population will regain their largest previous population. The proximity of the basin to the highly industrialized area of the Kanawha River and the Charleston metropolitan area makes the Coal River Basin susceptible to a future influx of population from these population centers.

Transportation facilities are good. Several State roads, including State Road No. 3, and one U. S. highway (U.S. 119) serve the basin in addition to the Chesapeake and Ohio Railway which connects the upper reaches of both Coal River and Little Coal River with the industrial area of the Kanawha River.

The economy of the basin depends primarily upon the coal industry. There are 16 coal washeries located within the basin. Many mines are not presently being worked, although excellent coal reserves still exist.

## WATER RESOURCES

The sites of the proposed reservoirs and the terrain of the basin are such that communities located in the Little Coal River sub-basin will not be affected by the proposed plans for low-flow augmentation.

In addition to those communities located within the Coal River Basin, adjacent areas were also considered in order to determine all interests in the water resources of the basin. The West Virginia Water Service Company serves customers in and adjacent to the lower Coal River Basin from their Nitro water treatment and distribution system which presently obtains raw water from the Kanawha River. Officials of the company have expressed a desire for raw water of better quality and have been looking to the Coal River for possible development.

In the portion of the basin which would be affected by increased low flows there are nine public water supplies serving approximately 22,000 persons using about 1.16 million gallons per day. The present average water consumption rate is 45 gallons per capita per day in small communities of the basin, and 55 gallons per capita per day in the Saint Albans area. Five of the public supplies are taken from surface water, while the other four are taken from wells. The surface water supplies presently serve approximately 21,800 persons with 1.15 million gallons per day. (See Table 1). Surface water for industrial use presently amounts to less than one million gallons per day.

TABLE 1

Domestic Water Supply Sources
Coal River Basin, West Virginia
(Not including communities located on Little Coal River)

| Community | Population Served 1/ 1956 | 1960 | Water Consumption 2/ (Gallons Per Day 1000's) 1956 | 1960 | Source of Supply |
|---|---|---|---|---|---|
| **SURFACE WATER SUPPLIES** | | | | | |
| Eccles | 2,500 | 1,000 | 112 | 45 | Out of basin |
| Montcoal | 1,100 | 600 | 49 | 27 | Marsh Fork |
| Whitesville | 1,280 | 1,904 | 63 | 65 | Coal River |
| Nellis (8 mos/yr) | 570 | 325 | 26 | 15 | |
| Saint Albans | 15,000 | 18,000 | 700 | 1,000 | Coal River |
| Totals | 20,450 | 21,829 | 950 | 1,152 | |
| **GROUND WATER SUPPLIES** | | | | | |
| Edwight | 400 | 44 | 18 | 2 | Drilled well |
| Marfork | 200 | 80 | 9 | 4 | " " |
| Dorothy | 165 | 80 | 7 | 4 | " " |
| Ameagle | 1,000 | 60 | 45 | 3 | " " |
| Totals | 1,765 | 264 | 79 | 13 | |

1/ Population values for both 1956 and 1960 are listed to show the recent decrease in population of small communities in the basin.

2/ In the absence of data for certain communities, water consumption was estimated according to known values in the basin.

Local residents in the basin indicate that the ground water level fluctuates appreciably, with some wells going dry during summer months. Private water supply wells in the vicinity of Seth, West Virginia, are 100 to 200 feet deep.

The presence of coal fines in the streams of the basin has, in the past, been a limiting factor in the utilization of water resources. Local residents indicate that fishing is presently poor and it is known that deposition of silt or similar material, such as coal fines, injures aquatic plant and animal life, and can seriously damage sources of fish food. Such deposits can also interfere with natural spawning activities of the fish. In addition, coal fines in a stream can interfere with the treatment of surface water for municipal and industrial uses.

Recent activities of the West Virginia Water Resources Commission have resulted in substantial reduction in amounts of coal fines discharged to the streams in the basin. The major accomplishments toward elimination of coal fines have been due to the installation of treatment facilities by coal washeries. Reduced coal mining activity has also played a part in the improvement of water quality. Some coal fines are still found in the streams following heavy rains due to "gob piles" (piles of waste coal) located along the stream banks. Until the piles along the banks have been stabilized or removed, coal fines will continue to enter the streams in the basin.

The lower stretch of the Coal River is within 15 miles of Charleston and is used extensively for recreation, including boating, bathing, and fishing. These water-use activities can be expected to increase as the water quality of the stream is improved.

## POLLUTION SOURCES

There are three principal types of pollution in the Coal River Basin. They are: (1) coal fines from coal washeries, (2) domestic sewage from sewered communities, and (3) domestic waste and garbage discharged in an uncontrolled manner along the banks of the streams.

A report on the Coal River Basin, prepared by the West Virginia State Water Resources Commission, indicates that coal washeries contributed approximately 550 tons of silt per day to the streams of the basin. 1/ This discharge of silt has since been greatly reduced and by March 1958, fifteen of the sixteen washeries in the Coal River Basin had treatment facilities of one type or another in operation. 2/

Table 2 indicates the principal sources of domestic sewage discharged to streams in the basin. Other communities in the basin are unincorporated and have no municipal sewage collection or treatment facilities.

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1/ Formerly West Virginia State Water Commission. Summary Report - Coal River Basin. Unpublished.

2/ West Virginia State Water Commission. News Bulletin. Volume 3, No. 1, March 1958.

TABLE 2

Principal Sources of Domestic Wastes
Coal River Basin, West Virginia

| Community | 1950 Population | Present Sewered Population | Present Status of Sewage Treatment Facilities | Receiving Stream |
|---|---|---|---|---|
| Whitesville | 1,017 | 800 | Plans complete for primary plant. | Coal River |
| Danville | 544 | 300 | No treatment. | Little Coal River |
| Madison | 2,025 | 2,100 | Primary plant completed to serve 3,340. | " " " |
| Fairview P.S.D. | - | - | Plans complete for primary plant to serve 1,200. | Coal River |
| Saint Albans | 9,870 | 6,000 | Plans complete for primary plant to serve 20,000. | Kanawha River |

## WATER QUALITY

### SURFACE WATER

Fluctuation in stream flow plays an important part in the quality of surface water in the Coal River Basin. Waste loads discharged to the streams during long periods of extremely low flow adversely affect water quality in the streams of the basin.

Records kept by the West Virginia State Department of Health indicate that the present quality of surface water in Marsh Fork from Montcoal to Whitesville, West Virginia, is as follows:

| Constituent | Average Range in Parts Per Million (ppm) |
|---|---|
| Alkalinity | 30 - 100 ppm |
| Total Hardness | 175 ppm (value at Montcoal) |
| pH | 6.4 - 8.2 |

Records for Saint Albans, West Virginia, show the present quality of water in the Coal River at the city water supply intake to be:

| Constituent | September 1960 | Yearly Average |
|---|---|---|
| Alkalinity | 20 - 40 ppm | 30 ppm |
| Total Hardness | 150 ppm | 85 ppm |
| Non-carbonate Hardness | 125 ppm | |
| pH | 7.0 | 6.7 |
| Turbidity | 20 ppm | 40 ppm |

Data on most probable numbers of coliform bacteria at Saint Albans indicate a range from 1600 to 8500 per one hundred milliliters.

Prior to 1957, the City of Saint Albans obtained its water supply from the Kanawha River; however, the City intake was moved to the Coal River in that year due primarily to water quality considerations.

GROUND WATER

Ground water in the Coal River Basin is generally of low quality, having high iron concentrations and appreciable amounts of hydrogen sulfide. Analyses of four ground water supplies in the basin, performed by the West Virginia State Department of Health, produced the following results:

| Constituent | Range | Average |
|---|---|---|
| Total Hardness | 68 - 342 ppm | 171 ppm |
| Iron | 0.1 - 3.0 ppm | 1.4 ppm |
| pH | 6.5 - 8.0 | 7.3 |

Total hardness of the ground water is moderately high and most water supply engineers agree that it is economical to soften water (remove hardness salts) when the total hardness exceeds about 150 ppm. The iron content of the water exceeds limits recommended in the Public Health Service Drinking Water Standards, which state that the combined iron and manganese content of water delivered to the distribution system should not exceed 0.3 parts per million. 3/

3/ U. S. Department of Health, Education, and Welfare, Public Health Service. Public Health Drinking Water Standards - 1946. Reprint No. 2697 from the Public Health Reports, Vol. 61, No. 11, March 15, 1946.

## PROPOSED WATER STORAGE

### RESERVOIR SITES

Two sites are under consideration for water storage reservoirs. One site is located on the upper reaches of Marsh Fork, and the second on the upper reaches of Clear Fork. These two reservoirs offer the three following possible plans for installation:

Plan I - Marsh Fork Reservoir only.

Plan II - Clear Fork Reservoir only.

Plan III - Construction of both reservoirs.

Plan I would control 45.8 square miles of drainage area, while Plan II would control 39.2 square miles of drainage area. Plan III would control 85.0 square miles of drainage area.

### LOW-FLOW AUGMENTATION

The following low-flow increases which could be developed from the planned reservoirs are considered in determining water supply and pollution abatement benefits:

| Plan | | Low Flow Increase (cfs) |
|---|---|---|
| I (a) | Marsh Fork Reservoir | 5.0 |
| (b) | " " " | 20.0 |
| II (a) | Clear Fork Reservoir | 5.0 |
| (b) | " " " | 20.0 |
| III (a) | Above confluence of Marsh Fork and Clear Fork | 20.0 * |
| (b) | Below confluence of Marsh Fork and Clear Fork | 40.0 * |

* Plan III is considered only for a maximum low-flow increase of 20.0 cfs in each reservoir.

Stream flow used in the State of West Virginia, for design of sewage treatment facilities is the minimum average seven-day low flow occurring on a ten-year frequency. Table 3 shows the design low flows and the total augmented flows in the Coal River Basin for the various plans, based on a design flow of 2.0 cfs at Ashford, West Virginia.

TABLE 3

Stream Flows

| Section of Stream | Design Flow (cfs) | Total Augmented Flow (cfs) PLAN I (a) | PLAN I (b) | PLAN II (a) | PLAN II (b) | PLAN III |
|---|---|---|---|---|---|---|
| MARSH FORK | | | | | | |
| Dist. 1 (Eccles) to Glen Daniel | 0.22 | 5.22 | 20.22 | | | Same as I(b) |
| Glen Daniel to Arnett | 0.23 | 5.23 | 20.23 | | | " " " |
| Arnett to Dry Creek | 0.25 | 5.25 | 20.25 | | | " " " |
| Dry Creek to Dist. 2 (Montcoal) | 0.27 | 5.27 | 20.27 | | | " " " |
| Dist. 2 (Montcoal) to Marfork | 0.29 | 5.29 | 20.29 | | | " " " |
| Marfork to Pettus | 0.61 | 5.61 | 20.61 | | | " " " |
| Pettus to Dist. 3 (Whitesville) | 0.71 | 5.71 | 20.71 | | | " " " |
| CLEAR FORK | | | | | | |
| Clear Creek to Dist. 5 (Ameagle) | 0.1 | 5.1 | 20.1 | 5.1 | 20.1 | Same as II(b) |
| Dist. 5 (Ameagle) to Dorothy | 0.2 | 5.2 | 20.2 | 5.2 | 20.2 | " " " |
| Dorothy to Dist. 3 (Whitesville) | 0.4 | 5.4 | 20.4 | 5.4 | 20.4 | " " " |
| COAL RIVER | | | | | | |
| Dist. 3 (Whitesville) to Orgas | 1.4 | 6.4 | 21.4 | Same as I(a) | Same as I(b) | 41.4 |
| Orgas to Dist. 4 (Seth) | 1.7 | 6.7 | 21.7 | " | " | 41.7 |

TABLE 3 - Continued

| Section of Stream | Design Flow (cfs) | Total Augmented Flow (cfs) | | | | |
|---|---|---|---|---|---|---|
| | | PLAN I | | PLAN II | | PLAN III |
| | | (a) | (b) | (a) | (b) | |
| Dist. 4 (Seth) to Nellis | 1.9 | 6.9 | 21.9 | Same as I(a) | Same as I(b) | 41.9 |
| Nellis to Ashford | 2.1 | 7.1 | 22.1 | " | " | 42.1 |
| Ashford to Alum Creek | 2.2 | 7.2 | 22.2 | " | " | 42.2 |
| Alum Creek to Tornado | 4.1 | 9.1 | 24.1 | " | " | 44.1 |
| Tornado to Saint Albans (W.S. Intake) | 4.3 | 9.3 | 24.3 | " | " | 44.3 |

Stream flow below Saint Albans' water intake will vary according to the amount of flow removed at that point for water supply purposes.

## AUGMENTATION BENEFITS

### AREAS BENEFITING BY ASSURED FLOW INCREASES

Certain communities are so located that it would be economically feasible for several of them to join together to form a public service district for the purpose of providing central water and waste treatment facilities. West Virginia law authorizes the formation of such districts for water supply or sewerage services in unincorporated areas. In addition, the West Virginia Water Resources Commission has recommended that public service districts be formed in the Coal River Basin to provide adequate sewage collection and treatment facilities. 4/ Therefore, for purposes of this study, it is assumed that where practicable small communities will join in the formation of public service districts to provide water and waste treatment facilities.

Calculations, incorporating anticipated future waste discharges and estimated natural assimilative capacity of the stream, indicate that Little Coal River would not discharge significant residual waste loads into Coal River. It is estimate that the dissolved oxygen content in Little Coal River, immediately above its confluence with Coal River, would be greater than 4.0 ppm (at design flow of 2.0 cfs at Ashford, West Virginia). Therefore, for purposes of this investigation, it is assumed that flow from Little Coal River will neither add to nor depreciate the dissolved oxygen resources of the Coal River.

4/ West Virginia State Water Commission. Summary Report - Coal River Basin. Unpublished - not dated.

Table 4 lists anticipated water supply needs and waste load discharges for communities and public service districts which will benefit from low-flow increases in the Coal River. The water supply needs are based on the following prediction of per capita water consumption in the basin:

Estimated Per Capita Water Consumption

| | 1960 | 1985 | 2010 |
|---|---|---|---|
| Small communities | 45 | 60 | 75 |
| Saint Albans area | 55 | 70 | 85 |

TABLE 4 - Benefiting Communities

PLAN I - Communities Affected by Marsh Fork Reservoir

| Name of Community (West Virginia) | Water Supply: Pop. Served 1960 | Pop. Served 2010 | Water Use Gallons/Day (1000's) 1960 | Water Use Gallons/Day (1000's) 2010 | Sewage Disposal: Est. PE Dischd. Prim. | Est. PE Dischd. Sec. | Est. BOD (lbs/day) Prim. | Est. BOD (lbs/day) Sec. |
|---|---|---|---|---|---|---|---|---|
| DISTRICT I | | | | | | | | |
| Harper | | 250 | | 18.8 | 163 | 50 | 29 | 9 |
| Eccles | 1000 | 2500 | 45.0 | 187.5 | 1625 | 500 | 292 | 90 |
| Surveyor | | 250 | | 18.8 | 163 | 50 | 29 | 9 |
| Dist. 1 Sub-Totals | 1000 | 3000 | 45.0 | 225.1 | 1951 | 600 | 350 | 108 |
| Glen Daniel | | 250 | | 18.8 | 125 | 125 | 22 | 22 |
| Arnett | | 300 | | 22.5 | 150 | 150 | 27 | 27 |
| Dry Creek | | 150 | | 11.2 | 75 | 75 | 14 | 14 |
| DISTRICT 2 | | | | | | | | |
| Hazy | | 200 | | 15.0 | 130 | 40 | 23 | 7 |
| Sundial | | 150 | | 11.2 | 98 | 30 | 18 | 5 |
| Edwight | 44 | 850 | 2.0 | 63.8 | 552 | 170 | 99 | 31 |
| Stickney | | 150 | | 11.2 | 98 | 30 | 18 | 5 |
| Montcoal | 600 | 1100 | 27.0 | 82.5 | 715 | 220 | 129 | 40 |
| Dist. 2 Sub-Totals | 644 | 2450 | 29.0 | 183.7 | 1593 | 494 | 287 | 88 |
| Marfork | 80 | 350 | 3.6 | 26.2 | 175 | 175 | 32 | 32 |
| Pettus | | 200 | | 15.0 | 100 | 100 | 18 | 18 |

TABLE 4 - Continued

PLAN I - Communities Affected by Marsh Fork Reservoir (Continued)

| Name of Community (West Virginia) | Water Supply: Pop. Served 1960 | Water Supply: Pop. Served 2010 | Water Supply: Water Use Gallons/Day (1000's) 1960 | Water Supply: Water Use Gallons/Day (1000's) 2010 | Sewage Disposal: Est. PE Dischd. Prim. | Sewage Disposal: Est. PE Dischd. Sec. | Sewage Disposal: Est. BOD (lbs/day) Prim. | Sewage Disposal: Est. BOD (lbs/day) Sec. |
|---|---|---|---|---|---|---|---|---|
| DISTRICT 3 | | | | | | | | |
| Whitesville | 1904 | 3000 | 65.0 | 225.0 | 1950 | 600 | 351 | 108 |
| Sylvester | | 250 | | 18.8 | 163 | 50 | 29 | 9 |
| Dist. 3 Sub-Totals | 1904 | 3250 | 65.0 | 243.8 | 2113 | 650 | 380 | 117 |
| Orgas | | 200 | | 15.0 | 100 | 100 | 18 | 18 |
| DISTRICT 4 | | | | | | | | |
| Seth | | 2400 | | 180.0 | 1560 | 480 | 281 | 86 |
| Comfort | | 250 | | 18.8 | 163 | 50 | 29 | 9 |
| Bloomingrose | | 200 | | 15.0 | 130 | 40 | 23 | 7 |
| Racine | | 200 | | 15.0 | 130 | 40 | 23 | 7 |
| Peytona | | 200 | | 15.0 | 130 | 40 | 23 | 7 |
| Dist. 4 Sub-Totals | | 3250 | | 243.8 | 2113 | 650 | 379 | 116 |
| Nellis | | 400 | | 30.0 | 200 | 200 | 36 | 36 |
| Ashford | | 400 | | 30.0 | 200 | 200 | 36 | 36 |
| Alum Creek | | 250 | | 18.8 | 125 | 125 | 22 | 22 |

TABLE 4 - Continued

PLAN I - Communities Affected by Marsh Fork Reservoir (Continued)

| Name of Community (West Virginia) | Water Supply: Pop. Served 1960 | Pop. Served 2010 | Water Use Gallons/Day (1000's) 1960 | Water Use Gallons/Day (1000's) 2010 | Sewage Disposal: Est. PE Dischd. Prim. | Est. PE Dischd. Sec. | Est. BOD (lbs/day) Prim. | Est. BOD (lbs/day) Sec. |
|---|---|---|---|---|---|---|---|---|
| Tornado | | 500 | | 37.5 | 250 | 250 | 45 | 45 |
| Fairview P.S.D. 1/ | 1000 | 2000 | 55.0 | 170.0 | 845 | 400 | 152 | 72 |
| Saint Albans | 18000 | 37000 | 1000 | 3140 | Waste Discharged to Kanawha River | | | |
| Nitro 2/ | | | | | | | | |
| Municipal | 45000 | 95000 | 2750 | 8550 | " | " | " | " |
| Industrial | - | - | 3000 | 15000 | | | | |
| Total | 45000 | 95000 | 5750 | 23550 | | | | |

1/ Fairview Public Service District will be served by the Nitro, West Virginia, water supply system. The District is located immediately upstream from Saint Albans, but will discharge its waste load downstream from the Saint Albans water supply intake.

2/ Water use data for the Nitro treatment plant is 1959 information furnished by the West Virginia Water Service Company.

TABLE 4 - Continued

PLAN II - Communities Affected by Clear Fork Reservoir

| Name of Community (West Virginia) | Water Supply: Pop. Served 1960 | Pop. Served 2010 | Water Use Gallons/Day (1000's) 1960 | Water Use Gallons/Day (1000's) 2010 | Sewage Disposal: Est. PE Dischd. Prim. | Est. PE Dischd. Sec. | Est. BOD (lbs/day) Prim. | Est. BOD (lbs/day) Sec. |
|---|---|---|---|---|---|---|---|---|
| Clear Creek | | 500 | | 37.5 | 250 | 250 | 45 | 45 |
| DISTRICT 5 | | | | | | | | |
| Ameagle | | 700 | | 52.5 | 455 | 140 | 82 | 25 |
| Colcord | | 300 | | 22.5 | 195 | 60 | 35 | 11 |
| Dist. 5 - Sub-Totals | | 1000 | | 75.0 | 650 | 200 | 117 | 36 |
| Dorothy | | 175 | | 13.1 | 88 | 88 | 16 | 16 |

NOTE: Plan II includes the communities listed above plus the communities listed under Plan I beginning with Whitesville.

PLAN III - Communities Affected by both Marsh Fork and Clear Fork Reservoirs

Plan III includes all communities listed in Plans I and II.

WATER SUPPLY BENEFITS

1. General

Water supply benefits resulting from an increase in water quantity and dependability are evaluated in terms of the cost of obtaining water of the same quantity and quality by the cheapest alternative means that would most likely be developed by the potential water users in the absence of the Federal project. The following alternates were considered in this study:

A. Savings in water treatment costs which could be realized by changing from an existing ground water source to a surface water source where adequate stream flow can be provided.

B. Savings in water treatment costs where existing surface supplies are inadequate and ground water is the only feasible alternate source.

C. Cost of a single-purpose water supply reservoir where this is the cheapest or only alternate means of obtaining an adequate water supply.

Ground water offers the most economical alternate supply for the smaller communities of the basin. A single-purpose water supply reservoir is the only satisfactory alternate source of supply for the Saint Albans-Nitro area.

Maintenance of water quality suitable for public water supply use must be assured if potential water users are to experience a

benefit for this purpose. For the Coal River to be suitable as a source of raw water for municipal supply, it will be necessary that all sewage be treated and provisions made for chlorination of treatment plant effluents. In view of West Virginia's active program for control of coal washery wastes, it is assumed that solids from this industry will be essentially eliminated from streams within the basin.

In order to prevent nuisance conditions, protect aquatic life, and to provide water of a quality suitable for domestic water supply, it is assumed for purposes of this evaluation that the minimum objective for dissolved oxygen content in the streams of the basin is 4.0 ppm. According to calculations incorporating minimum stream flows and estimated future waste discharges, this objective would not be met in all reaches of Coal River.

The cost of supplying water to the consumer varies significantly depending upon location of the source, quality of raw water and amount of treatment required, cost of chemicals, power, labor, etc., in the area and relative size of the treatment facility. A study of water supply costs in the Coal River Basin and adjacent areas revealed that the average customer cost per million gallons of surface water supplied to communities of the size found in the upper Coal River Basin is about $800 per million gallons. The average customer cost of Coal River water for Saint Albans, West Virginia, is about $680 per million gallons based on a present plant

output of 1.0 million gallons per day. Saint Albans, having only recently changed from the Kanawha River as a raw water source to the Coal River, has estimated that the cost to treat Coal River water is about $90 per million gallons less than the cost to treat Kanawha River water.

Ground water supplies in the Coal River Basin have not been developed to an extent great enough to furnish adequate cost data. Such supplies in the adjoining Guyandot Basin are more extensively developed, providing basic cost figures for well water treatment costs. Due to the similarity and proximity of the two basins, the costs for treatment of ground water in the Guyandot Basin have been used, with adjustment for known lower iron content found in the Coal River Basin. 5/ A customer cost of $965 per million gallons will be used to estimate the cost of ground water supplies.

The customer costs presented above include operation and maintenance costs as well as amortization, including interest, of the capital cost of the water supply systems.

2. Discussion of Benefits

Water supply benefits for the various plans of low-flow augmentation are shown in Tables 5 through 7.

5/ U. S. Department of Health, Education, and Welfare, Public Health Service. Investigation of the Guyandot River Basin - Report on Benefits to Water Supply and Pollution Abatement from Low-Flow Augmentation on the Guyandot River and Tributaries. Cincinnati, Ohio: Robert A. Taft Sanitary Engineering Center, June 1959.

The evaluation of water supply benefits for the public service districts shown in Table 4, pages 19 through 22, is based on the savings in water treatment costs that could result from the use of a dependable source of surface water in lieu of existing or alternate ground water sources. Any of the proposed plans for flow augmentation would provide a dependable source of surface water supply for these districts. The costs of pipeline joining the communities of the districts to the central systems are to be included in the cost of surface water supply. These costs are shown in Column 5, Tables 5 through 7. Where the total cost of surface water supply exceeds the cost of ground water supply, no water supply benefit can be shown.

District 1 (Eccles) presently is supplied by a private water company which purchases water from the Beckley, West Virginia, municipal supply. This supply, which is adequate to meet future needs of the district, is located outside of the Coal River Basin and, thus, no water supply benefit can be shown for District 1.

Since Nitro has indicated that the Coal River is being considered as a source of water supply, it is assumed, for purposes of this study, that Nitro will utilize Coal River water if a dependable supply is made available. In the absence of low-flow augmentation, the only alternate dependable source of supply for Saint Albans and Nitro is a single-purpose water supply reservoir. It has been estimated that the most economical site for such a reservoir is on the Little Coal River about 17.5 miles above the mouth of Coal River and

about 900 feet above the mouth of Little Coal River. 6/ This site is approximately 14 miles upstream from the Saint Albans raw water intake.

All single-purpose water supply reservoir costs included in this report were developed by the Corps of Engineers, Huntington District, at the request of and in consultation with the Public Health Service. The annual costs shown are based on an interest rate of 4½ per cent, a 50-year project life, and include operation and maintenance costs.

A low-flow increase of 5 cfs, developed from Plan I(a) or Plan II(a) could provide a dependable source of supply for Saint Albans through the year 2010. The annual cost of a single-purpose reservoir to provide this flow (5 cfs) would be $54,700.

Plan I(b) or Plan II(b)-(20 cfs flow increase) could provide a dependable source of supply for Saint Albans to the year 2010, and could also supply 40 per cent of Nitro's projected 2010 water needs (adequate for Nitro until 1975). The annual cost of a single-purpose reservoir providing the same quantity of flow (20 cfs) would be $99,100. Based on the amounts of water needed by each, the proportionate shares of the annual cost of such a reservoir would be $26,800 for Saint Albans and $72,300 for Nitro.

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6/ Developed by the Corps of Engineers, Huntington District, at the request of and in consultation with the Public Health Service.

Plan III, providing a low-flow increase of 40 cfs, could, within the limits of probable error in predictions, be considered sufficient to supply the anticipated 2010 water needs of both Saint Albans and Nitro. An alternate single-purpose reservoir to produce the same assured minimum flow (40 cfs) would have a total annual cost of $156,300. Based on the proportionate amount of water needed by each, Saint Albans' share of the annual cost of such a reservoir would be $18,500 and Nitro's share would be $137,800.

An evaluation of the alternate sources of dependable water supply for Saint Albans and Nitro indicates that the cheapest and most reasonable alternate is the joint installation of a single reservoir to supply the combined needs of both water supply systems. For example, Saint Albans could, on an individual basis, install a reservoir to supply an assured flow of 5 cfs at an annual cost of $54,700, while the same quantity of water could be obtained from a joint project with Nitro at an annual cost to Saint Albans of only $18,500. Therefore, based on the most economical and reasonable alternate, the annual water supply benefit to Saint Albans from any of the plans for low-flow augmentation is the proportionate share of the cost of such a joint alternate project.

Plan III is the only one of the proposed plans that could supply the projected 2010 water needs of Nitro, and the annual benefit to Nitro from this plan is the proportionate share of the cost of the joint alternate project. The low-flow increases that

could be developed from Plans I(a) and II(a) would be adequate to supply the projected 2010 water needs for Saint Albans only. As previously stated, Plans I(b) or II(b) would meet Nitro's projected water needs only until 1975, and it is unlikely that Nitro would, in the absence of the Federal reservoir, participate in such a short-term project. Therefore, in view of the amount of dependable water supply that could be developed by the various plans for low-flow augmentation, a water supply benefit to Nitro is listed only under Plan III.

TABLE 5

Water Supply Benefits for
Plan I(a) Providing 5 cfs Flow Increase from Marsh Fork Reservoir
Plan I(b) Providing 20 cfs Flow Increase from Marsh Fork Reservoir

| Community or District (1) | Water Use MG/Yr (2) | ANNUAL COST OF WATER SUPPLY | | | | (Col. 3-6) Difference in Cost of Ground Water and Surface Water (7) | Annual Water Supply Benefit | |
|---|---|---|---|---|---|---|---|---|
| | | Ground Water Alternate (3) | Surface Water | | | | Plan I(a) | Plan I(b) |
| | | | Surface Supply (4) | Pipeline to Serve District (5) | Total for Surface Water (6) | | | |
| District 2 (Montcoal) | 67.1 | $ 64,750 | $ 53,680 | $ 14,200 | $ 67,880 | $ - 3,130 | $ -0- | $ -0- |
| District 3 (Whitesville) | 89.0 | 85,900 | 71,200 | 8,500 | 79,700 | 6,200 | 6,200 | 6,200 |
| District 4 (Seth) | 89.0 | 85,900 | 71,200 | 17,100 | 88,300 | - 2,400 | -0- | -0- |
| Saint Albans | 1460 | (Annual cost of single-purpose reservoir) | | | | | 18,500 | 18,500 |
| Nitro | 8300 | --- | --- | --- | --- | --- | -0- | -0- |
| | | TOTAL ANNUAL BENEFIT | | | | | $24,700 | $24,700 |

TABLE 6
Water Supply Benefits for
Plan II(a) Providing 5 cfs Flow Increase from Clear Fork Reservoir
Plan II(b) Providing 20 cfs Flow Increase from Clear Fork Reservoir

| Community or District (1) | Water Use MG/Yr (2) | ANNUAL COST OF WATER SUPPLY: Ground Water Alternate (3) | Surface Water: Surface Supply (4) | Surface Water: Pipeline to Serve District (5) | Surface Water: Total for Surface Water (6) | (Col. 3-6) Difference in Cost of Ground Water and Surface Water (7) | Annual Water Supply Benefit: Plan II(a) | Annual Water Supply Benefit: Plan II(b) |
|---|---|---|---|---|---|---|---|---|
| District 5 (Ameagle) | 27.4 | $ 26,440 | $ 21,920 | $ 5,600 | $ 27,520 | $ - 1,080 | $ -0- | $ -0- |
| District 3 (Whitesville) | 89.0 | 85,900 | 71,200 | 8,500 | 79,700 | 6,200 | 6,200 | 6,200 |
| District 4 (Seth) | 89.0 | 85,900 | 71,200 | 17,100 | 88,300 | - 2,400 | -0- | -0- |
| Saint Albans | 1460 | (Annual cost of single-purpose reservoir) | | | | | 18,500 | 18,500 |
| Nitro | 3100 | --- | --- | --- | --- | --- | -0- | -0- |
| | | TOTAL ANNUAL BENEFIT | | | | | $ 24,700 | $ 24,700 |

TABLE 7
Water Supply Benefits for Plan III
Providing 40 cfs Flow Increase from Both Reservoirs

| Community or District | Water Supply Benefit |
|---|---|
| District 2 (Montcoal) | $ -0- |
| District 3 (Whitesville) | 6,200 |
| District 4 (Seth) | -0- |
| District 5 (Ameagle) | -0- |
| Saint Albans | 18,500 |
| Nitro | 137,800 |
| TOTAL ANNUAL BENEFIT | $162,500 |

## POLLUTION ABATEMENT BENEFITS

In West Virginia, the stream flow used for the purpose of designing sewage treatment facilities is the minimum 7-day flow with a recurrence frequency of 10 years. This design flow in the Coal River at Ashford, West Virginia, is calculated to be 2.0 cfs.

If a stream receives waste loads in excess of the maximum loading which can be assimilated under design low flow conditions without reducing the dissolved oxygen content below the objective 4.0 ppm, a pollution abatement benefit can be derived for augmented stream flow. Pollution abatement benefits are not assigned, however, where low-flow augmentation would substitute for sewage treatment works required by State or local authorities or contemplated in comprehensive pollution control plans prepared under the Federal Water Pollution Control Act.

In the Coal River Basin, the State Water Resources Commission is, at the present time, requiring a minimum of primary treatment. As the communities grow and waste loads increase, it is assumed that the addition of secondary treatment will be required.

For the purpose of evaluating pollution abatement benefits, certain assumptions are made as follows:

1. Public service districts, formed to provide water supply facilities, will also install sewage collection and treatment facilities.

2. Primary treatment facilities will serve communities and public service districts during the first 15 years of the 50-year life of the proposed water storage project.
3. Primary treatment plants will be expanded to secondary facilities after 15 years and, therefore, secondary treatment will be in effect for the remaining 35 years of the project life.
4. A waste discharge of 0.17 pounds of 5-day Biochemical Oxygen Demand (BOD) per capita per day is assumed. All waste loads were converted, however, to pounds of ultimate BOD to facilitate the use of exponential equations in determining the assimilative capacity of stream flow. At 25°C the ultimate BOD is approximately 0.18 pounds per capita per day.
5. Primary treatment is assumed to remove 35 per cent of the daily BOD load and secondary treatment is assumed to remove 80 per cent of the daily BOD load.
6. Through agreement with the West Virginia State Water Resources Commission, waste loads from unsewered communities are considered to be discharged into adjacent streams in an amount equal to 50 per cent of the total estimated community population equivalent.

Benefits assigned to low-flow augmentation are based on the equivalent costs (difference between primary and secondary treatment) to remove one pound of BOD per day per year by conventional treatment. Treatment plant cost data were adjusted to current value by use of Engineering News Record cost index. 1/

According to accepted procedures for calculating the assimilative capacity of streams, the ultimate BOD in the Coal River and tributaries cannot exceed 15.5 ppm ($BOD_5$-Day = 14.4 at 25°C), if a dissolved oxygen concentration of not less than 4.0 ppm is to be maintained in all sections of the streams.

Calculations of the assimilative capacity of augmented flows and consideration of expected future waste loads indicate that a flow increase of about 4.7 cfs would be required to assimilate the maximum expected waste load in the main stem of Coal River and maintain a dissolved oxygen content of 4 ppm or more. To maintain the objective dissolved oxygen content (not less than 4 ppm) in Marsh Fork and Clear Fork, flow increases of approximately 4.2 cfs and 1.5 cfs respectively, would be required.

Table 8 lists the calculated maximum allowable ultimate BOD loads (for design and augmented flows) for the various stream sections. Anticipated waste load discharges to the streams were previously shown in Table 4, pages 19 through 22. Table 9 lists the waste loads assigned to low-flow augmentation. These are the BOD loads (pounds per

1/ Construction Cost Index of 830.48 (1913 = 100) was used. Engineering News Record, Vol. 165, No. 24, December 15, 1960.

day) which must either be removed by treatment or assimilated by stream flow in order to maintain the objective dissolved oxygen content (4.0 ppm) in the stream.

The pollution abatement benefits for the various plans of low-flow augmentation are listed in Table 10. Since Plan I(a) or Plan II(a), providing a flow increase of 5 cfs, would be adequate to assimilate the maximum expected waste loads in the Coal River during the life of the proposed Federal project, greater flow increases that could be developed from Plan I(b) or Plan II(b), (20 cfs each), or Plan III (40 cfs), would provide no additional pollution abatement benefits. The greater flows would, however, have potential value in terms of the capacity of the flows to assimilate additional waste loads (BOD) above and beyond those predicted.

TABLE 8
Maximum Allowable Ultimate BOD Loads to Maintain
4.0 ppm Dissolved Oxygen

| Section of Stream | MAXIMUM ALLOWABLE ULTIMATE BOD (lbs/day) At Design Flow | At Augmented Flow PLAN I (a) | PLAN I (b) | PLAN II (a) | PLAN II (b) | PLAN III |
|---|---|---|---|---|---|---|
| MARSH FORK | | | | | | |
| Eccles to Glen Daniel | 18.4 | 437 | 1692 | - | - | Same as I(b) |
| Glen Daniel to Arnett | 19.3 | 438 | 1693 | - | - | " " " |
| Arnett to Dry Creek | 20.9 | 439 | 1695 | - | - | " " " |
| Dry Creek to Montcoal | 22.6 | 441 | 1697 | - | - | " " " |
| Montcoal to Pettus | 24.3 | 443 | 1698 | - | - | " " " |
| Pettus to Whitesville | 59.4 | 478 | 1733 | - | - | " " " |
| CLEAR FORK | | | | | | |
| Clear Creek to Ameagle | 8.4 | - | - | 427 | 1682 | Same as II(b) |
| Ameagle to Dorothy | 16.7 | - | - | 435 | 1691 | " " " |
| Dorothy to Whitesville | 33.5 | - | - | 452 | 1707 | " " " |
| COAL RIVER | | | | | | |
| Whitesville to Orgas | 117. | 536 | 1791 | Same as I(a) | Same as I(b) | 3465 |
| Orgas to Seth | 142. | 561 | 1816 | " | " | 3490 |
| Seth to Ashford | 159. | 578 | 1833 | " | " | 3507 |
| Ashford to Alum Creek | 184. | 603 | 1858 | " | " | 3532 |
| Alum Creek to Tornado | 343. | 762 | 2017 | " | " | 3691 |
| Tornado to St. Albans (W.S. Intake) | 360. | 778 | 2034 | " | " | 3708 |
| Below St. Albans (W.S. Intake) | Maximum allowable ultimate BOD loads below the St. Albans water supply intake will vary according to the amount of stream flow removed for water supply at that point. | | | | | |

TABLE 9
Waste Loads Assigned to Low-Flow Augmentation
Coal River

| Stream Section | Stream Load (Lbs. Ult. (BOD) | | LOADS ASSIGNED TO AUGMENTATION | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Plans I(a) and I(b) | | Plans II(a) and II(b) | | Plan III | |
| | Prim. | Sec. | Prim. | Sec. | Prim. | Sec. | Prim. | Sec. |
| MARSH FORK | | | | | | | | |
| Eccles to Glen Daniel | 350 | 108 | 330 | 90 | - | - | 330 | 90 |
| Glen Daniel to Arnett | 45 | 30 | 5 | 5 | - | - | 5 | 5 |
| Arnett to Dry Creek | 35 | 30 | 10 | 10 | - | - | 10 | 10 |
| Dry Creek to Montcoal | 25 | 25 | 0 | 0 | - | - | 0 | 0 |
| Montcoal to Pettus | 290 | 90 | 270 | 65 | - | - | 270 | 65 |
| Pettus to Whitesville | 160 | 85 | 5 | 5 | - | - | 5 | 5 |
| CLEAR FORK | | | | | | | | |
| Clear Creek to Ameagle | 45 | 45 | - | - | 40 | 40 | 40 | 40 |
| Ameagle to Dorothy | 125 | 40 | - | - | 100 | 20 | 100 | 20 |
| Dorothy to Whitesville | 50 | 40 | - | - | 0 | 0 | 0 | 0 |
| COAL RIVER | | | | | | | | |
| Whitesville to Orgas | 510 | 190 | 320 | 55 | 380 | 70 | 310 | 50 |
| Orgas to Seth | 120 | 55 | 0 | 0 | 0 | 0 | 0 | 0 |
| Seth to Ashford | 425 | 140 | 240 | 0 | 240 | 0 | 240 | 0 |
| Ashford to Alum Creek | 135 | 90 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alum Creek to Tornado | 40 | 30 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tornado to St. Albans (W.S. Intake) | 70 | 65 | 0 | 0 | 0 | 0 | 0 | 0 |
| Below St. Albans (W.S. Intake) | 190 | 105 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTALS | | | 1180 | 230 | 760 | 130 | 1310 | 285 |

TABLE 10

Pollution Abatement Benefits by Time Periods
Coal River

| Plan | Minimum Flow Increase (cfs) | BOD Loads Assigned to Low-Flow Augmentation (lbs/day) | | AUGMENTATION BENEFITS | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | ANNUAL | | TOTAL FOR TRMT. PERIOD | | |
| | | Prim. Trmt. | Sec. Trmt. | Prim. Trmt. Period (15 yrs.) | Sec. Trmt. Period (35 yrs.) | Prim. Trmt. Period (15 yrs.) | Sec. Trmt. Period (35 yrs.) | Total Project Benefit |
| I(a) | 5 | 1180 | 230 | $ 21,800 | $ 4,250 | $ 327,000 | $ 148,800 | $ 475,800 |
| (b) | 20 | 1180 | 230 | 21,800 | 4,250 | 327,000 | 148,800 | 475,800 |
| II(a) | 5 | 760 | 130 | 14,100 | 2,400 | 211,500 | 84,000 | 295,500 |
| (b) | 20 | 760 | 130 | 14,100 | 2,400 | 211,500 | 84,000 | 295,500 |
| III | 40 | 1310 | 285 | 24,200 | 5,300 | 363,000 | 185,500 | 548,500 |

Comparison of pollution abatement benefits discloses that flow augmentation under Plan I would produce greater benefits than it would under Plan II. This is true because Marsh Fork (Plan I) affects more communities and a greater population than Clear Fork (Plan II). Plan III provides the greatest pollution abatement benefit since both Marsh Fork and Clear Fork would be affected.

## DISCUSSION

This report presents preliminary estimates of water supply and pollution abatement benefits which could accrue from low-flow augmentation in the Coal River Basin, West Virginia. Although of a preliminary nature, it is felt that the report presents values which are reasonable estimates based on available information and basic assumptions necessary to its preparation.

The nature of the Coal River Basin is such that maximum pollution abatement benefits would be realized by communities in the upper reaches of the basin, while maximum water supply benefits would be realized in the area adjacent to the mouth of the river. The water supply benefits assignable to low-flow augmentation would be substantial, primarily because of the need for a dependable source of good quality water in the Saint Albans-Nitro area.

Flow augmentation in the Coal River Basin would contribute to improved water quality in the Kanawha River; thus, a small additional tangible benefit could be realized. The determination of this small additional benefit is beyond the scope of this study.

Low-flow augmentation would also provide intangible benefits in terms of improved stream water quality, over and above the minimum water quality objectives.

Development of the proposed reservoirs in the Coal River Basin could stimulate the development of the area and would provide added recreational attractions.